

implied—and its hypothesis assumed—that Mars had a magnetic field, but that was not known 10 years ago.

“By proposing that these magnetites were formed by magnetotactic bacteria, as we wrote in the original paper, that implied that Mars had a magnetic field,” said McKay. “At the time we published that paper, it was thought that Mars did not have a magnetic field. Yet these magnetites, if our hypotheses were correct, predicted that we would find that Mars had a magnetic field. In fact within about two years, the orbiting spacecraft detected very strong magnetic strips of rock on the surface. And the interpretation is that those magnetic strips of rock were magnetized by an early strong core magnetic field on Mars that magnetized and then went away at about 4 billion years and younger, leaving these strips. You might say that our paper predicted evidence for a magnetic field on early Mars would be found.”

NEW TOOLS, NEW TECHNIQUES

In addition to responding to critics of the magnetite argument, the JSC ALH84001 team has spent years refuting those who have posited nonbiological explanations for the team's other three lines of evidence. For example, critics have claimed that the PAHs resulted from Antarctic ice, not Martian ice. But the JSC team and other groups have shown that while as much as 80 percent of the organic PAHs in the rock did come from water flowing through the Antarctic ice, at least 20 percent bears chemical signatures from Mars. Moreover, these signatures are concentrated in the tiny area of the rock where the JSC scientists claimed existence of life.

The key point, as the JSC team asserts, is that all of the noted biological evidence—the complex carbonate minerals, the PAHs, the magnetites—is in one tiny place in the meteorite. To the team, nonbiological alternative explanations cannot account for all of these features occurring in one place.

“To explain these properties, all in the same place, by a nonbiological explanation, seems to me to be extremely difficult, if not impossible,” said McKay. “And nobody has done that. The one group that has tried to explain the magnetite has tried to make organics by heating. And as far as I know, they haven't done that. They tried to make these PAHs, and they have not been able to do that. My point is that there are very complex features there, and they're all in this one little tiny area, and taken together only one explanation seems to explain them all rather easily. And all these other explanations may explain one or two but not the whole set.”

Using tools that did not exist 10 or even five years ago, the JSC scientists continue to study the Martian meteorite and other meteorites from Mars. They are using a new laser analyzer and an analytical electron microscope to examine the Martian samples in new ways. For example, today JSC scientists are able to identify a small section within a sample, cut it out without destroying the sample, lift it out and place it into another instrument for further analysis and then take that same examined section and place it into a second or third instrument to do additional analyses.

“It's analogous to, say, a deck of cards,” said Thomas-Keptra. “If the carbonate is the deck of cards, we can essentially take one card out of the deck now and look at it whereas before we could never

do anything like that. So we've got some very interesting techniques now that we're able to use that weren't available five years ago.”

Studies will yield a new wave of data that the team hopes will substantiate its initial claims. “We think we're getting new results which, in almost every case, support our hypothesis,” says McKay. “What we have learned is that it is a lot more complex than we thought at first. But so what? Life is complex, and the fingerprint of life is also complex.”

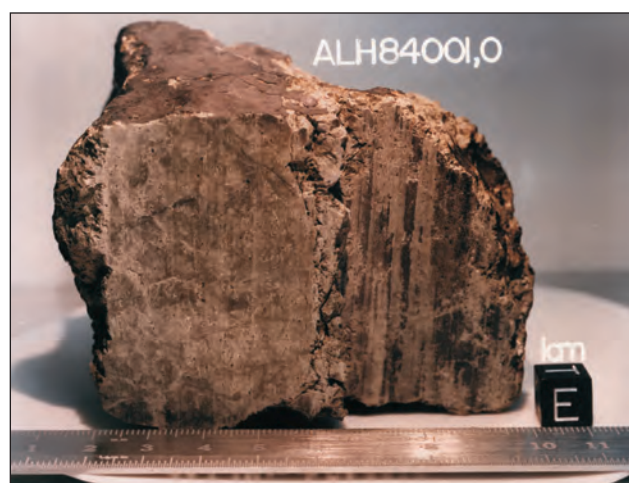
The scientists hope that future studies will help them build a very strong, if not irrefutable, case for their hypothesis.

“Our greatest progress in the next few years will be to detect those organic carbon areas and relate them to the fossil-like features that we see—if they do relate,” said McKay. “We don't know that they will, but if they do relate that will be very strong evidence that these are truly micro fossils.”

“The other area that we need new techniques is in carbon isotope analysis. What we want to do is not only show that these carbon areas have the chemistry of micro fossils, we want to show that they are from Mars and not contamination from Earth. And the only way to do that is with the isotopic data. And so I would like to go in that direction. That would be such strong evidence that no one could dispute that. If we can show that there is organic carbon and the organic carbon comes from Mars, and it's the same kind of organic carbon that you get today in micro fossils from Australia, but this can't be from Australia, it's got to be from Mars, and, furthermore, it's associated with all these other features, I think we could build a very strong case.”

Scientists still argue over the presence of signatures of life in Allan Hills, but they agree that ALH84001 forced NASA and other institutions across government, industry and academia to search for answers to very weighty questions: Are we alone? Is there or has there ever been life elsewhere? And if so, how did it begin?

McKay and his colleagues continue to search for answers to these questions.



Older than any known rock from Earth, meteorite ALH84001, was discovered in 1984 in the Allan Hills region of Antarctica. One of 38 meteorites discovered on Earth thought to be from Mars, it is a softball-sized igneous rock weighing 1.9 kilograms (4.2 pounds). ALH84001 is 4.5 billion years old.



Paper meets technology

by Brandi Dean

R*aymond Aronoff would like you to take a moment and think back to the movie “Apollo 13.”*

There’s a scene, just after everything has gone wrong, where everyone jumps up and starts trying to fix it. Books, models and diagrams are dumped on the table, providing the blueprint for saving the day.

FAST FORWARD 30 or 40 years, though, and it might not be that simple.

“Today we’re no longer a paper-based world,” said Aronoff, former chief technology officer for the Engineering Directorate.

Most of the time, that statement is associated with progress, but technological advancement is creating an interesting challenge: while NASA is transitioning from paper documents, digital technology is advancing rapidly.

NASA is straddling the boundary between the paperless and paper-based world. In an emergency today, rather than turning to books and diagrams, everyone in Mission Control and Engineering would head to their computers. But they might not find what they need.

“The problem is, (NASA’s) programs last decades,” he said. “But two years is a decade in the software world.”

Music fans should be able to relate. You develop a library of eight-track tapes only to have it become obsolete with the invention of cassette tapes. And then it happens all over again with the advent of compact discs. But for NASA, it's critical information on spacecraft design that becomes inaccessible rather than the greatest hits of the 1970s.

So, a lot of information is stored in hard copy. But paper has its own problems. You can't do a "search" for a particular word or phrase in a traditional book—you have to read it all instead. You also can't upload a piece of paper into an engineer's simulation program—you have to recreate the design.

And it's difficult to cross-reference hard copies effectively. A card catalog is nice, but electronic versions have the capability to be directly linked to each other—double clicking on a citation could take you straight to the work in question.

WORKING TOGETHER

So the solution is not to fight paperless offices, it's to refine them. Patrick McDuffee, Integrated Engineering Capability Project Manager at Marshall Space Flight Center (MSFC), is working with Aronoff to do just that.

McDuffee calls what they are creating a "collaborative environment for engineering data"—a way for engineering data on different projects and in different centers to be stored so that everyone who might need it could access it.

For instance, much of the responsibility for the new crew exploration vehicle falls to Johnson Space Center. But the propulsion part of it is MSFC's domain. The two centers will want to work closely on it, but that can be tricky.

"In the past, that would be really labor intensive," McDuffee said. "You'd have to make a physical trip to the other center or maybe mail the information. And you might just throw up your hands and hire a contractor do to the work just because (the contractor's) closer."

But if JSC and MSFC had a way to share the data electronically and a

common method of building and saving it, McDuffee said everyone could work on it together in real time.

Bill Harris, technical manager for the Engineering and Science Contract, said the idea has the potential to prevent a lot of headaches. If different groups are able to participate during the design process, technical review goes more quickly, engineering rework is more easily avoided and problems are less likely to get into the system.

Plus, the ability to electronically store the technical review decisions creates a historical record of the evolution of the design—which can be very valuable in future engineering assessments.

"The electronic environment becomes a very efficient and effective process to develop intellectual products," Harris said. "We are actively working with our Jacobs contractor team to electronically develop and deliver all engineering products in a collaborative environment. Basically, we have come a long way in converting to a paperless system. I have very little paper in my office, and it's getting smaller every day."

INSTANT ACCESS

Harris, Aronoff and McDuffee also believe that it's only going to become more important down the road, as NASA heads deeper into space.

"So these guys are on their way to Mars," Aronoff postulated. "Let's say our grandkids. And let's say they break something. How are you going to get them a replacement part?"

That's why the engineering chief always had a starring role on "Star Trek," Harris said. Whenever anything went wrong, he could pull up the schematics and solve the problem in real time. He didn't wait for someone on Earth to tell him how—he fixed it himself.

"In order to do that, you have to have the raw engineering data with you," Harris said.

If all the engineering data for the mission is stored in one form that can be opened by a particular set of programs,

it can be put on a disc for the crew to use while on Mars. You could radio the data instead, but with so much information it would be a prohibitively slow process.

Getting to the point where all the data is compatible and accessible is also a slow process, however. Aronoff said the issue has to be worked both inside and outside of NASA—and at the rate it's going, the change will probably take a couple of decades to pull off.

STAYING POWER

Many of the same tools used by NASA and its contractors are used by other industries such as telecommunications and automotive. But, cell phones are out of date in a matter of months, not decades. Manufacturers don't need access to their design models for long. Even automobile manufacturers, whose designs are expected to last longer, pass the responsibility of keeping up with old parts over to others.

"It's not a cost savings for the other industries to have longevity of design like that required at NASA," Aronoff said. "We're significant, but we're not the only customer base for these technology providers."

NASA's internal challenges are no less difficult. Organizations will have to rethink the way that they initiate, collaborate on and manage engineering information. It's going to be expensive and complex, and call for a willingness to change and a new level of cooperation across centers and projects.

"That doesn't happen easily or quickly," Aronoff said. "It requires patience and persistence at every level of the organization."

Even so, Aronoff said that he's seeing progress.

"Because our visions demonstrate objectives beyond the moon, we're realizing the severity of this issue, and understanding the importance of dealing with it," he said. "We're making some headway."



NASA tests technology in the Arizona desert

Arizona's famed Meteor Crater and Cinder Lake area recently served as a surrogate planet surface for NASA's Desert Research and Technology Studies (RATS) team of scientists and engineers. The RATS team took to the desert to test spacesuits and robotic equipment, as well as to simulate a day in the life of a surface exploration crew on the moon or Mars.



Space Center Roundup

The Roundup is an official publication of the National Aeronautics and Space Administration, Johnson Space Center, Houston, Texas, and is published by the Public Affairs Office for all Space Center employees. The Roundup office is in Bldg. 2, Rm. 166A. The mail code is AP411. Visit our Web site at: <http://www.jsc.nasa.gov/roundup/online/> For distribution questions or to suggest a story idea, please call 281/244-6397 or send an e-mail to jsc-roundup@mail.nasa.gov.

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